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STUDIES ON MYRMECOPHILES. I. CREMASTOCHILUS.

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The phlegmatic beetles of the exclusively North American genus *Cremastochilus* have been extensively collected by coleopterists, but very little study has been devoted to their habits. And though all collectors know that these beetles, of which some twenty-five species have been described, are regular myrmecophiles, it is a rare experience to find one of them mounted with its host ant in a collection. Indeed, with the exception of a few data published several years ago (1890) by one of our eminent coleopterists, Dr. A. E. Schwarz, I can find no records of the species of ants among which the *Cremastochili* pass so much of their lives. I therefore publish the following observations in the hope that they may induce some of our entomologists to make accurate notes of their future captures of these extraordinary insects.

Mr. L. H. Joutel having kindly identified the *Cremastochili* in my collection, I am able to present the following records of fourteen species, including those mentioned by Schwarz :

1. *Cremastochilus spinifer* Horn. — A single specimen taken June 6, 1902, from a nest of *Pheidole desertorum* Wheeler under a stone in the desert near Fort Davis, Texas.

2. *C. wheeleri* Lec. — Taken repeatedly during July and August, 1903, and 1906 at Colorado Springs, Manitou and Boulder, Colo., in the nests of *Formica oreas* Wheeler, *crinita* Wheeler, *microgyna* Wheeler and its variety *rasilis* Wheeler, *ciliata* Mayr, and *rufa* L. subsp. *obscuripes* Forel.

3. *C. crinitus* Lec. — Taken repeatedly during May, 1903, by Messrs. C. T. Brues, A. L. Melander and myself near Austin, Texas, in the nests of *Formica fusca* L. var. *gnava* Buckley.

4. *C. retractus* Lec. — Also taken at Austin in nests of *F. gnava*, but much less frequently than *C. crinitus*. I have also taken it (July 19, 1903) in nests of *F. ciliata* at Colorado Springs.

5. *C. harrisi* Kirby. — Mr. Wm. Beutenmüller has given me a few specimens of this beetle which he took in the Black Mts. of North Carolina in nests of *Formica pallidefulva* Latr. subsp. *schaufussi* Mayr. I have also found it as late as September 16, at Lakehurst, N. J., in a

colony of *F. sanguinea* L. subsp. *rubicunda* Emery var. *subintegra* Emery, with *F. schaufussi* as slaves.

6. *C. canaliculatus* Kirby. — Taken in the following localities and with the following ants: Newfoundland, N. J. (April 27, 1907), with *F. schaufussi*, and *rubicunda*, with *fusca* L. var. *subsericea* Say as slaves (Davis and Wheeler); Westfield, N. J. (May 18), with *F. exsectoides* Forel (Davis); Andover, Mass., with *F. subsericea* (A. P. Morse).

7. *C. castaneæ* Knoch (Fig. 1). — Occurring, like the preceding, with a number of species of *Formica*: Black Mts., N. C., with *F. subsericea* (W. Beutenmüller); Newfoundland, N. J. (April 27, 1907), with *F. schaufussi* and *exsectoides* (Davis and Wheeler); Washington, D. C., with *F. rufa* subsp. *integra* Nyl. (Schwarz); same locality with *F. schaufussi* (Pergande); Bronxville, N. Y. (April 19, 1904; April 19, 1908), with *F. schaufussi* and with *Polyergus rufescens* Latr. subsp. *lucidus* Mayr with *F. nitidiventris* Emery as slaves (Wheeler); Greenville, N. Y. (July 30, 1904), with *F. subsericea* (Wheeler); Westfield, N. J. (May 18), with *F. exsectoides* (Davis); Cañon City, Colo. (March 23), with *F. fusca* var. *argentina* Wheeler (Rev. J. Schmitt).

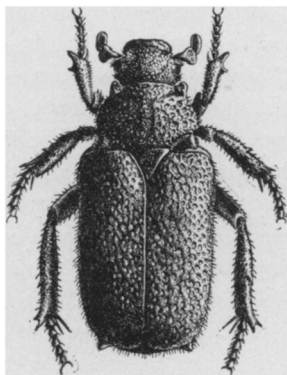


FIG. 1. *Cremastochilus castaneæ* Knoch. $\times 4$.

8. *C. mexicanus* Schaum. — Taken by Mr. C. Schaeffer in the Huachuca Mts. of Arizona, in a nest of *F. gnava*, and by Mr. H. A. Wenzel in the same locality in nests of *F. rufa obscuripes* var. *rubiginosa* Emery.

9. *C. variolosus* Kirby. — Recorded by Schwarz as occurring in nests of *Stenamma (Aphenogaster) fulvum* Roger.

10. *C. squamulosus* Lec. — This species, which occurs in Georgia and Florida, is cited by Schwarz as living with *Camponotus esuriens*, an ant which does not occur in the United States. What has been passing under this name is in all probability *C. abdominalis* Fabr. var. *floridanus* Buckley or one of the southern forms of *C. maculatus* Fabr.

11. *C. planatus* Lec. — This and the two following species were taken during July and August by Mr. H. A. Wenzel in Miller Cañon, Huachuca Mts., Ariz. (5,000 to 6,000 ft.) in nests of *F. rubiginosa*.

12. *C. planipes* Horn.

13. *C. opaculus* Horn.

14. *C. ineptus* Horn. — Mr. H. W. Wenzel informs me that this species was taken in the same locality as the three preceding species and with the same ant by Mr. H. Kaeber.

These records show that in the great majority of cases the hosts of *Cremastochilus* belong to the genus *Formica*. Although *C. spinifer* has been taken with *Pheidole*, *C. variolosus* with *Aphaenogaster* and *C. squamulosus* with a species of *Camponotus*, it is practically certain that these are accidental or irregular associations. Hence we should expect the beetles to be found only within the geographical range of the genus *Formica*, and this appears to be the case. Even the four species cited in the "Biologia Centrali-Americana" (*C. saucius*, *planatus*, *mexicanus* and *crinitus*) occur within the United States, and have been taken in Mexico only on the high northern plateau where *Formica* also occurs. It is not improbable that some or all species of *Cremastochilus* prefer to live with particular species of *Formica*, but this cannot be proved without a great many more records than I have been able to obtain heretofore.

Haldeman (1848) seems to have been the first to publish an account of the occurrence of *Cremastochilus* in ant-nests, but the correspondence of Hentz, Say and Harris published by Scudder in 1869, shows that as early as 1825 Hentz had seen ants dragging a specimen of the beetle over the ground. Horn (1871) says that he found *C. schaumi* and *angularis* "very frequently in ants'-nests and in one instance apparently eating the pupæ. Several times I have seen large black ants dragging specimens of *schaumi* along the surface of the ground towards their nests and on examination have frequently succeeded in obtaining from nests specimens that had previously been dragged there. Why these insects are found with ants is a question to which I am not prepared to give a definite answer, unless, as I suspect, the fossæ at the anterior angles and the finely punctured and apparently perforated patches under the hind angles are glandular and yield some secretion grateful to the ants." The patches to which Horn alludes are tufts of golden yellow or orange-red hairs, the trichomes, which characterize so many myrmecophilous insects, and are most beautifully shown on various parts of the body in beetles of the genera *Adranes*, *Claviger*, *Paussus*, *Lomechusa*, *Xenodusa*, etc.

In 1886 Horn published some additional notes on the habits of

Cremastochilus. He received from J. J. Rivers, of California, a specimen of *C. schaumii* with the posterior thoracic angles mutilated, and from J. Hamilton, of Allegheny, Pa., one of *C. canaliculatus* in a similar condition. Concerning these specimens he writes as follows : "It is my belief that the irregularities in the Rivers and Hamilton specimens are the work of the ants, with which the specimens were found and I have long held the opinion and have so published it, that the pubescent depressed spaces near the front and under the hind angles of most of the species, are glandular, and give a secretion very palatable to the ants, and these almost reasoning insects, finding the processes in their way have deliberately removed them, either partially, as in the Rivers specimen, or entirely as in the other." Horn also quotes from Schwarz the following interesting observation on a species of *Cremastochilus* which was apparently living with *Formica exsectoides* : "In May, 1883, while on an excursion in the vicinity of Washington, I came across a large ant hill constructed by a species of *Formica* which is allied to, but not identical with, *F. rufa*. My attention was at once attracted by three objects on top of the ant hill, which at first glance appeared to be compact masses of ants. Upon looking closer to each of the masses proved to consist of a living *Cremastochilus* attended by numerous ants which held on with their mandibles to the legs, the head, the sides of the thorax of the beetles, in short wherever there was a chance for them to hold on. That they did not intend to do any harm to the beetles was evident, and it seemed to me that they intended to prevent the escape of the *Cremastochili* from their colony. Herein they were evidently successful, as upon waiting for a considerable length of time there was no change in the situation. I then proceeded to investigate the interior of the ant hill, which consisted of numerous layers of intricate galleries and chambers, all built of rather loose earth without any sticks or other debris. Within the chambers several more *Cremastochili* were found but not attended to by ants."

Hamilton (1888-1889), in his excellent list of myrmecophilous insects, cites a number of species of *Cremastochilus* but without the names of their hosts. Of *C. canaliculatus* he says, that it is the most abundant species at Allegheny, Pa. "It is found from April till June with large black ants, perhaps of two species, inhabiting usually under stones or other covering, but not infrequently throwing up small mounds in old pastures and open ground. The nests under

stones rarely yield more than two beetles, but the mounds often contain five or six at once, and with care will yield a crop every two or three weeks. The beetles are found near the surface, none having been taken below the plane of the base. As soon as it becomes warm, from the middle of April onward, this species takes leave of the ants and flies away; like the *Cicindelæ* it only flies during the hottest sunshine and for short distances, alighting suddenly on a stone or the middle of a dusty road. Its flight is low and heavy, and after it lights cannot take wing again without some delay, and I have seen it flying as late as August. Whether after having left, the same beetles return and breed among the ants, or whether it is a new brood that claims their hospitality for the winter, is absolutely unknown. I never could satisfy myself as to whether those found in the nests in June had returned or were just preparing to leave."

In 1891 Luggar published a few observations on *C. knochi* Lec. which he found at St. Anthony Park, Minnesota. He saw the beetles mating during the early spring in an open field and being dragged about by ants (species not mentioned). One individual "was found sitting right over one of the small entrances of an ant nest. With slow and very deliberate actions the beetle gradually enlarged the hole under it, and in the course of nearly seven hours disappeared from view." Luggar figures a peculiar cavity which was excavated in the earth by five pairs of *C. knochi* kept in a jar.

The observations above cited are all or nearly all that have been published on the habits of *Cremastochilus*. In order to ascertain the relations of these beetles to the ants I have on several occasions installed specimens of *C. crinitus* in artificial nests with *F. gnava* and of *C. canaliculatus* and *castaneæ* with *F. subsericea*, *schaufussi*, *nitidiventris* and *integra*. Beetles kept with the colonies in which they are first taken, are treated with complete indifference by the ants. This is sometimes the case also when the beetles are placed in a strange colony of the same species of *Formica*, especially if this is *F. schaufussi*. More frequently a different picture, like that seen in the following experiment, is exhibited: April 19 I placed two *C. castaneæ*, that had passed the winter with *F. schaufussi*, in a Fielde nest containing several hundred workers and two deälated queens of *F. integra*. The beetles at once "feigned death" and remained for several minutes lying on their backs, with retracted legs and antennæ. They were not noticed till they stretched out their appendages and began to walk

about. Then the ants at once pounced upon them with open mandibles and curved their gasters forward between their hind legs, in the attitude assumed by all the forms of *F. rufa* when irritated and about to discharge their formic acid. There could be no doubt that the ants were hostile and irritated but nevertheless the acid batteries were never called into action, probably because there is a disinclination to use these organs within the narrow confines of the nest. They contented themselves with biting the beetles and pulling their legs. It soon became apparent, however, that the biting was largely restricted to the posterior corners of the beetle's thorax. The ant clung to the side of the beetle in the position shown in Fig. 2, seized the posterior angle between its mandibles in such a manner that the toothed border of one mandible fitted into the arcuate groove which separates the angle from the more convex portion of the thorax, and then moved its head from side to side in a vigorous attempt to tear away the triangular piece of chitin bearing the cushion of trichomes on its ventral surface. Several of the workers busied themselves thus for periods varying from one to twenty minutes, and one pertinacious individual gnawed at the posterior thoracic angle of the same beetle for an hour and a quarter. The anterior angles and the legs were also gnawed and pulled, but much less frequently and persistently. With a pocket lens it was possible to study the mouth-parts of the gnawing ant. There was no attempt to lick any portion of the beetle's body. In fact, the ant, while gripping the thoracic angle, kept its mouth tightly closed and held its maxillary palpi back against the gula while the labial palpi, with a rhythmic movement approached, but did not actually touch, the trichomes. The gnawing seemed to irritate or, at any rate, to stimulate the beetle, for it stalked rapidly about the nest carrying the ant on its back. Whenever the anterior part of its body was touched by an ant, it quickly retracted its antennæ, so that it could never be seized by these appendages. Eventually it managed to force its head and thorax into a corner or under the wet sponge.

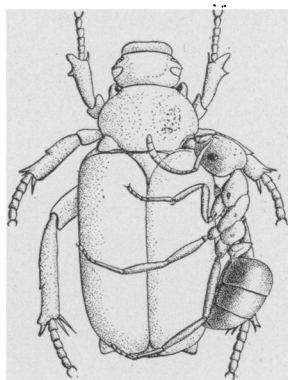


FIG. 2. *Cremastochilus castaneae* with *Formica integra* worker gnawing at one of its posterior thoracic angles. $\times 4$.

Then the ant had to release its hold. Sometimes it continued to gnaw at the exposed abdomen, elytra or legs, but sooner or later it left the beetle to its own devices. The creature then remained for hours in somnolent quiescence till some enterprising ant would pull it out of its ostrich-like concealment by one of its hind legs and the gnawing at the posterior thoracic angles and the march of the beetle around the nest would recommence.

The beetles were observed daily for several weeks. At times I was inclined to believe that the ants had grown accustomed to their presence and were beginning to tolerate them with indifference, but closer observation showed that whenever the beetles left their retreat and wandered about the nest they were sure to be assaulted by a few of the ants and to have their thoracic angles gnawed till they again succeeded in concealing themselves. This behavior on the part of the ants continued without modification till June 10 and 13, when the two beetles died and were placed on the refuse heap by the *integra* workers.

A specimen of *C. castaneæ* was also placed in a nest of *F. subsericea*. Though this ant has a much more cowardly disposition than *F. integra*, it nevertheless attacked the beetle as soon as it spread its legs and proceeded to move about the nest. There was the same gnawing at the posterior thoracic angles as exhibited by *integra*, but more pulling at the beetle's legs. The *subsericea* workers treated the beetle much as they treat an alien queen: each seized a leg and then, fixing its claws in the towelling or sponge of the nest, began to pull. As the mandibles of *subsericea* are weaker than those of *integra*, there was even less danger of injury to the beetle, which dragged the ant along till it found a corner in which it could bury its head and thorax and enjoy a spell of immunity from their attacks.

The imaginal *Cremastochili* seem to require no food. At any rate, I have never seen them eating any substances in the nests or being fed by the ants, although I have kept them under observation from three to seven weeks. Some of the nests in which they were confined contained ants' eggs and young larvæ, but these were completely ignored by the beetles. In the natural nests the latter are sometimes present in much greater numbers than is suggested by Hamilton's statement above quoted. April 27, 1907, at Newfoundland, N. J., Mr. Wm. T. Davis and I took from a single nest of *F. schaufussi* 24 *Cremastochui*, belonging to two species, *castaneæ* and *canaliculatus*.

This is the more surprising because the colonies of *schaufussi* are very small compared with those of *subsericea*, *integra*, *exsectoides*, etc.*

From the foregoing observations we may conclude that the *Cremastochili* are not true guests, or symphiles, as Wasmann supposed (1894), but persecuted intruders (synechthrans) that may eventually become indifferently tolerated guests (synœketes). This explains the observations of previous writers. The three *Cremastochili* which Schwarz found arrested by the *F. exsectoides* workers were, in all probability, individuals that had only just alighted on the mound, whereas those taken in the galleries of the nest were old inhabitants. The specimens with defective thoracic angles, described by Horn, had probably been mutilated by the ants, as he suggests. Such mutilations, however, would hardly be possible except in individuals that had just escaped from their pupa-cases and were still soft. The view here advocated is supported by the remarkable development of the protective devices of the *Cremastochili*: their hard armor, the extraordinary cup-shaped mentum which prevents the ants from getting at the mouth-parts and the facility with which they can withdraw their antennæ into deep grooves on the sides of the head.

But if this view is accepted, how are we to interpret the tufts of yellow hairs, or trichomes on the thoracic angles, their obvious fasciation for the ants and the peculiar oily red "myrmecophile color" of some of the species (*C. saucius* and *spinifer*)? That the thoracic angles represent adaptations to myrmecophily can hardly be doubted. I have called attention to the remarkable manner in which these structures, at least in some of the species, fit the mandibles of the *Formica* workers. As the glands on these angles unquestionably emit some odor which simultaneously attracts and irritates the ants, one would be inclined to account for their development by supposing that they tend to withdraw the hostile attentions of these insects from more vulnerable organs.† But what are these organs? All parts of the

* Mr. Davis calls my attention to the fact that Hamilton's statements in regard to the flight of *Cremastochilus* are not strictly applicable to all the species. A considerable number of *C. harrisi* were seen by Mr. Davis during the past April flying along the roads in the sandy pine barrens at Lakehurst, N. J. They were very agile and difficult to catch, taking flight again after alighting with as much ease as *Cincindela*.

† It is interesting to note that the European and North American species of an allied genus of Cetoniine beetles, *Osmoderma* (*O. eremita* L., *eremicola* Knoch and *scabra* Beauv.), have long been noted for their peculiar odors. Concerning our

beetles' surface are thoroughly indurated and equally adapted to repelling the mandibular onslaught. There seems to be only one way out of the difficulty thus presented by the simultaneous development of these protective and alluring adaptations in the *Cremastochili*, and that is to regard these beetles as degenerate symphiles, forms that were once true guests, with more highly developed trichomes and living on much more amicable terms with their hosts. In having fallen from this estate they resemble certain species of *Paussus* that have been studied by Escherich. *Cremastochilus* has, in fact, all the ear-marks of a very senile genus. Its species, like somber hypochondriacs, are condemned by an ancient instinct to dwell in the busy emmet world without participating in its splendid activities. The weariness of a long and eventful evolution seems to lurk in their hard, pock-marked integument and rheumatic joints. Having outlived a period of abject sycophancy, they would, perhaps, return to a free and independent life, were it not that their brains have been enfeebled by too many generations of parasitism.

Nothing is known concerning the development of *Cremastochilus*. The larval and pupal stages are passed, in all probability, in the ant-nests, and from what has been learned of allied forms, like *Cetonia*, we should expect to find the larva in the vegetable débris of the nest. July 22, 1903, while examining a nest of *Formica microgyna* in Williams Cañon near Manitou, Colorado, I found besides a number of adult *C. wheeleri*, a single Cetoniine larva, which may be that of this beetle. It was buried in the vegetable débris and on being exposed by a stroke of my trowel, was at once seized and injured by the irate ants. It resembles rather closely the larva of *Osmoderma eremita* figured by Schiödte (De Metamorphosi Eleutheratorum Observationes, VIII, 1874, Tab. XI, Fig. 1). If it is the larva of *C. wheeleri* it is only about two thirds grown.

The mating of *Cremastochilus* sometimes takes place in the ant-nests. At any rate I have seen pairs of *C. castaneæ* and *canaliculatus* in copulâ in the outer galleries of *F. schaufussi* nests in April. Liebeck (1899) took the mating sexes of *C. leucostictus* Burm., which are

American species Harris (A Treatise on Some of the Insects Injurious to Vegetation, 1862, p. 42) says: "They have the odor of Russian leather, and give this out so powerfully that their presence can be detected by the scent alone, at the distance of two or three yards from the place of their retreat." This scent is retained for years in cabinet specimens.

very dissimilar, in the open field, and it is probable that this is the more usual mating place. The beetles undoubtedly spend much of their adult life with the ants. They certainly hibernate in the nests as they were found both by Hamilton and myself in the early spring (middle of April) in the upper galleries. Moreover, the dates above mentioned (p. 68) show that they may be found in the nests as late as July, August and September. It is probable, therefore, that the eggs are laid in May and that the adult beetles make their appearance towards the middle or latter part of the summer and then remain with their hosts till the following spring.

The genus *Cremastochilus* belongs to the Cetoniine subfamily of the Scarabæidæ and has its closest allies, curiously enough, in certain South African genera. These are in part myrmecophilous and in part termitophilous. To the former group belong *Plagiochilus intrusus* Wasmann (1900), *P. argenteus* Wasm. and *Myrmecochilus marshalli* Wasm. (Fig. 3), both occurring in the nests of a very common South African ant, *Plagiolepis custodiens*. To the latter group belong five species of *Cænochilus* (*termiticola* Wasm., *braunsi* Wasm., *glabratus* Boh., *hospes* Péringuey and *intrusus* Pér.). In this same region there are also a number of other myrmecophilous and termitophilous Cetoniinæ not so closely allied to *Cremastochilus*. Péringuey (1900) mentions *Placodidus compransor* and *Trichoplus schaumii* as occurring in the nests of *Plagiolepis*, and species of *Scaptobius* and *Lissogenius* as myrmecophiles. The same author surmises that *Trichostetha capensis* is termitophilous, and one who has seen this remarkable green and black beetle, which measures nearly 30 cm. in length and has its ventral surface covered with great tufts of orange-red hairs, can hardly doubt that it lives with ants or termites.

Other myrmecophilous Cetoniinæ occur both in Europe and in North America. In the former country the larvæ and pupæ of *Cetonia floricola* Herbst are very common in the nests of *Formica rufa* and *pratensis*; and in the United States, as Schwarz has shown, *Euphoria inda* L., *hirtipes* Horn and probably also *E. pilosicollis*

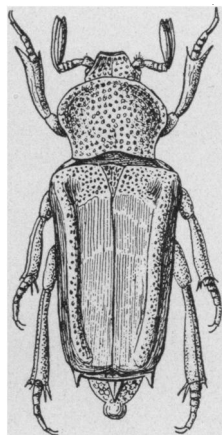


FIG. 3. *Myrmecochilus marshalli* Wasm. $\times 4$.
(After Wasmann.)

breed in ant-nests. The larva of *E. inda* is recorded from nests of *Formica integra* and the adult from those of *F. rufa obscuripes*. During the spring of 1906, while watching a large nest of *F. exsectoides*, I saw a *E. inda* fly from a distance, alight on the mound and at once bury itself out of sight in the earth and vegetable debris. *E. hirtipes* has also been taken in the nests of *F. obscuripes* by Bruner. It appears, therefore, that all the myrmecophilous Cetoniinæ have a predilection for ants of the genus *Formica* or of the allied genus *Plagiolipsis*, which represents *Formica* in South Africa. That this predilection is exhibited by so many genera of the subfamily and in such widely separated regions as South Africa, Europe and North America, shows that it must be of very ancient origin.

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NEW SPECIES OF NOCTUIDÆ FOR 1908. I. WITH NOTES ON CHARADRA, RAPHA AND PSEUDANARTA.

BY JOHN B. SMITH, SC.D.,

NEW BRUNSWICK, N. J.

CHARADRA Wlk.

There are now five species in our fauna which seem properly referable to this genus, and these may be distinguished as follows:

Secondaries white or whitish, more or less infuscated outwardly.

Primaries with median lines connected by a more or less obvious line; t. a. line with an outward dentation at its middle.

Orbicular conspicuously black centered.

Primaries smooth, even dark gray, without strong contrasts; secondaries almost uniformly white.....*ingenua*.

Primaries whitish, black powdered, contrastingly marked; secondaries a little stained, especially in female, and outwardly darker.

deridens.

Orbicular not conspicuously black centered; maculation not strongly contrasting, secondaries of ♀ dusky throughout.....*sudena*.

Primaries with median lines not connected; t. a. line upright, without an outward dentation at middle.....*dispulsa*.

Secondaries yellow at base, with a determinate outer black marginal band.....*patens*.

Ingenua Sm., is the largest of these species and is from Colorado. The smooth, even, glistening gray primaries distinguish it readily, and the black markings are not conspicuously contrasting.